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Final Technical Report for NASA Grant NAG 5 1664

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The purpose of this grant was to support reduction and analysis of data obtained with the ROSAT satellite on two stars, V471 Tau and V795 Her.

V795 Her is a cataclysmic variable with an orbital period of 0.1082648 d, which was determined from its spectroscopic radial velocity curve. The light curve of V795 Her is modulated at a period of 0.1164865 d, about 7.5% longer than the orbital period. The source of the photometric period is uncertain. One possibility is that the photometric period is caused by precession of a non-axisymmetric accretion disk around the white dwarf. The difference in period is consistent with the period difference measured for other cataclysmic variables with precessing accretion disks. The other possibility is that the white dwarf in V795 Her is magnetized so that the matter accreting onto the white dwarf is forced to fall onto the magnetic poles. An accretion shock makes the poles bright and rotation of the white dwarf then modulates the light received from the white dwarf. In this model the modulated flux at optical wavelengths must be reprocessed off other parts of the system, and the observed photometric period is the beat period between the orbital period and the rotation period of the white dwarf.

X-ray observations should distinguish between these two models. If the photometric period is caused by a precessing accretion disk, V795 Her should have a relatively weak X-ray flux. If the photometric period is caused by rotation of a magnetized accreting white dwarf, the X-ray flux should be strong and it should be strongly modulated. Accordingly, we asked for and received time on ROSAT to measure the X-ray light curve of V795 Her. The observation was successful and the data are in hand.

The first stages of the data reduction are done. There is a moderately strong X-ray source at the position of V795 Her:

$$\alpha = 17^{\mathrm{h}}\ 12^{\mathrm{m}}\ 56.0^{\mathrm{s}} \pm 0.1^{\mathrm{s}}$$
$$\delta = 33^\circ\ 31'\ 19.2'' \pm 1.3''$$
$$\mathrm{J2000}$$

The photon flux is 0.01018 ± 0.00102 cps. This moderately strong flux would appear to favor the rotating, magnetized white dwarf model.

At this stage of the reductions I ran into two difficulties. The first was that the calibrations for ROSAT were not yet in a final form, so I could not reliably convert the photon flux from V795 Her to an energy flux. The second was that the time-series software package in the PROS system was still preliminary and full of bugs. Because these are not issues that a GO observer on ROSAT can handle, I was forced to interupt my work on the data. At the time of this writing (December

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1992), both issues appear to have been resolved, and I have every expectation that the remaining analysis will proceed smoothly and that the results on V795 Her will be published in a timely way.

V471 Tau is a binary system consisting of a K-type main sequence star and a hot DA white dwarf. The orbital period, $\approx$11.5 h, is long enough that the K star is detached from its Roche lobe. Both the optical and X-ray light curves of V471 Tau are modulated at a period of 555 seconds. At the time of our request for ROSAT observations there were two viable models for the 555 second modulation: 1) the white dwarf in the system could be pulsating in a non-radial g-mode or 2) the white dwarf could be spotted and rotating. The spot model would require the white dwarf to have a magnetic field and to be accreting metal-rich material from the wind emitted by the K star.

The two models can be distinguished by comparing the phases and precise periods of the X-ray and optical light curves. The optical and X-ray data must be contemporaneous for the comparison to be meaningful. We asked for and received time on ROSAT to observe the X-ray light curve of V471 Tau, and a colleague of ours at Texas, Mr. C. Clemens, obtained extensive ground-based observations of the optical light curve.

The ROSAT observations were successful. Our preliminary analysis of the data showed that the X-ray light curve of V471 Tau is strongly modulation at the 555-second period. Because of the continuous improvement – and consequent continuous recalibration – of the data, we did not, however, receive all the data in their final form until April, 1992, less than three months before the termination of this grant. In the interim, new ground-based observations and observations with the ROSAT Wide Field Camera have shown that the spot model is correct. The nature of the project has, therefore, changed. We now are using the ROSAT and optical data to map the positions and sizes of the spots over the surface of the white dwarf in the two wavelength regions. The spot model requires that the spots be comparable in size, but the spots must be dark spots at X-ray wavelengths and bright spots at optical wavelengths. The high quality ROSAT X-ray data will allow a definitive test of this prediction.

We are mapping the spots using maximum entropy techniques. I have written the maximum entropy program and I have calculated the map of the optical spots; my colleagues at Goddard Space Flight Center are preparing the X-ray data for mapping. The remaining analysis and the preparation of the results for publication should proceed smoothly and rapidly.

In summary, the ROSAT observations for this project were successful. Delays in the ROSAT calibrations and problems with the PROS software package initially delayed the reduction and analysis of the data, but the data analysis is now proceeding smoothly. Two papers reporting the results of this investigation are in active preparation.